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Introduction

Madam Chair and Members of the Subcommittee, my name is Robert Hennekes. I am Market Development Manager, Gas & LNG, for Shell Global Solutions (US) Inc. and a Vice President of Technology Marketing for Shell Global Solutions, a network of independent technology companies that specialize in cutting-edge technologies. I would like to talk a little more about some of those technologies and how they might contribute to meeting the nation's energy needs in an efficient and environmentally responsible way.

Shell Global Solutions (US) Inc., a wholly-owned subsidiary of Shell Oil Company, is located at the Westhollow Technology Center in Houston, Texas. The Shell Global Solutions network is comprised of Shell Global Solutions (US) Inc., Shell Global Solutions International B.V. (operating out of The Hague and Amsterdam (Netherlands), and with sister companies in Thornton (England), Petit Couronne (France), Hamburg (Germany), Kuala Lumpur (Malaysia) and Singapore). Each specializes in its own areas of expertise, and, through service agreements, support each other with research data, operational experience, technical know-how and staff who are top professionals in their own disciplines. When a client contacts any of the companies in Shell Global Solutions, it benefits from the resources of all of them.

Our Experience

I am delighted to have the opportunity to share a little of what we do here in Houston as a center of excellence for technical service in non-traditional energy issues. Shell Global Solutions (US) Inc. provides technical services to third parties, Shell-owned companies and Shell joint ventures including gas transmission companies, chemical and

LNG plants, hydrocarbon distribution companies and oil exploration and production facilities.

Shell Global Solutions (US) Inc. provides services in three different areas:

First, we offer Shell technology and successful practices through comprehensive Technical Service Agreements (TSAs). This comprehensive set of services takes the Shell know how, experience, and successful practices and brings it to a company to help increase its margins and efficiencies and to lower its cost structure.

Second, we provide specific services designed to satisfy a companies' individual needs. One example would be providing assistance in a companies' review of its LNG facilities.

Finally, we license industry-leading technologies in gasification, and risk based pipeline assessment methodology.

Shell Licensed Gasification

Gasification is a very versatile process that converts a variety of carbon-containing feedstocks like coal, petroleum coke, lignite, oil distillates, residues and natural gas into synthesis gas by partial oxidation with air or oxygen. Shell has developed two dedicated gasification technologies, the Shell Gasification Process (SGP) for liquid and gaseous feedstocks and the Shell Coal Gasification Process (SCGP) for solid feedstocks, such as coal, lignite and petroleum coke. Both processes have been successfully applied commercially. Gasification projects select Shell technologies due to their high efficiency, versatile applicability, and performance, in addition to the technological know-how and operational experience of Shell Global Solutions.

Shell Gasification Process

Shell originally developed the Shell Gasification Process (SGP) to provide syngas for the chemical industry, e.g., for the production of fertilizer. The syngas can also be used for its combustion value. Feed flexibility, environmental performance, and the ability to use low cost feedstock are important drivers that support further application of this technology for power generation and hydrogen manufacturing in refineries.

In the early years, feeds were usually rather light distillates, but residues became more attractive due to their low cost. Adjustments to the process, such as the development of an improved Soot & Ash Removal Unit, extended the technology to the application for the manufacture of syngas from refinery-derived heavy residues such as those from vacuum distillation, visbreaking and solvent de-asphalting.

The main processes in a gasification system are the gasification, in which the feedstock is reacted with oxygen and steam to raw syngas, the syngas cooling, the sour syngas treatment, and the carbon handling system.

The non-catalytic partial oxidation of hydrocarbons by SGP takes place in the gasifier equipped with a specially designed burner. This design provides for more efficient gas-liquid mixing and a better flame temperature control.

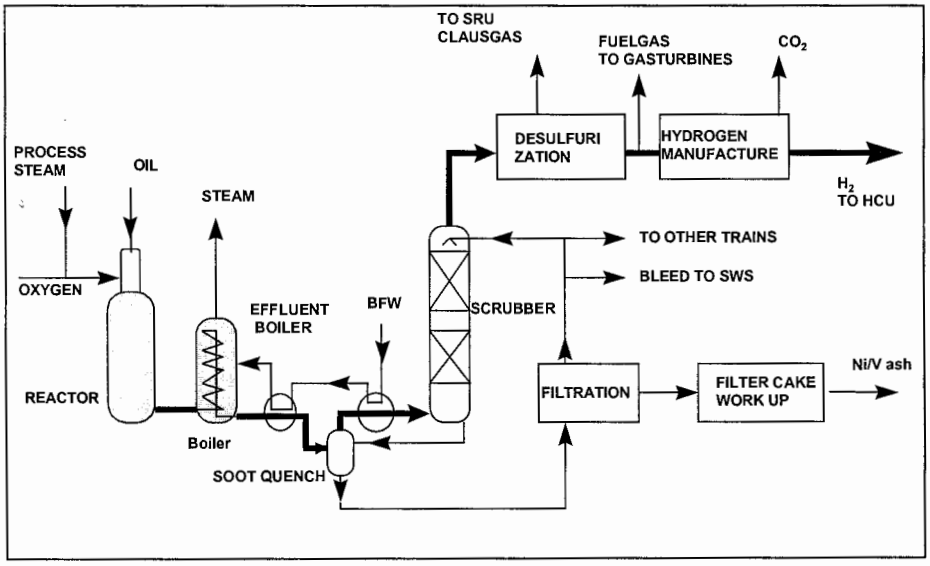


Figure 1 - A typical line-up of an SGP Gasification plant for hydrogen production

Figure 1 shows a typical structure of an SGP gasification plant for hydrogen production. Presently, 82 SGP reactors are producing about 62 million Nm3 syngas per day in 26 plants worldwide. This is equivalent to 23,000 tons of residue per day or nearly 8 million tons of residue per year.

Shell Coal Gasification Process

For gasification of solid feedstocks, a dedicated development program has resulted in the commercially marketed Shell Coal Gasification Process (SCGP). The process is characterized by the following features:

- Dry feed of pulverized coal,
- Compact gasified and other equipment due to the pressurized, entrained flow, oxygen blown concept,
- Slagging, membrane wall gasifier which allows high temperatures because of insulation and protection of wall by solid inert slag layer,
- Multiple, opposed burners resulting in good mixing of coal and blast, large turndown, and large scale-up potential.

The typical syngas product consists of 25-30 % of hydrogen and 60-65 % of carbon monoxide. High-pressure steam is produced in the gasification and heat recovery section and can be used, e.g., to generate electricity in the IGCC (Integrated Gasification Combined Cycle) application, thus increasing the efficiency of the whole process. Other by-products are inert slag, elemental sulfur, and relatively small amounts of clean water effluent. As an alternative to discharging the effluent water, it may be evaporated to give a zero water discharge and salts as by-products. The slag and sulfur can readily be marketed.

The process can handle a wide variety of solid feedstocks, ranging from lignite, brown coal, sub-bituminous coal, bituminous coal, anthracite, to petroleum coke. Coal types can be switched during operation. Over the wide range of coal properties processed, the SCGP process has proven to be insensitive to the size, condition, or other physical properties of the raw coal.

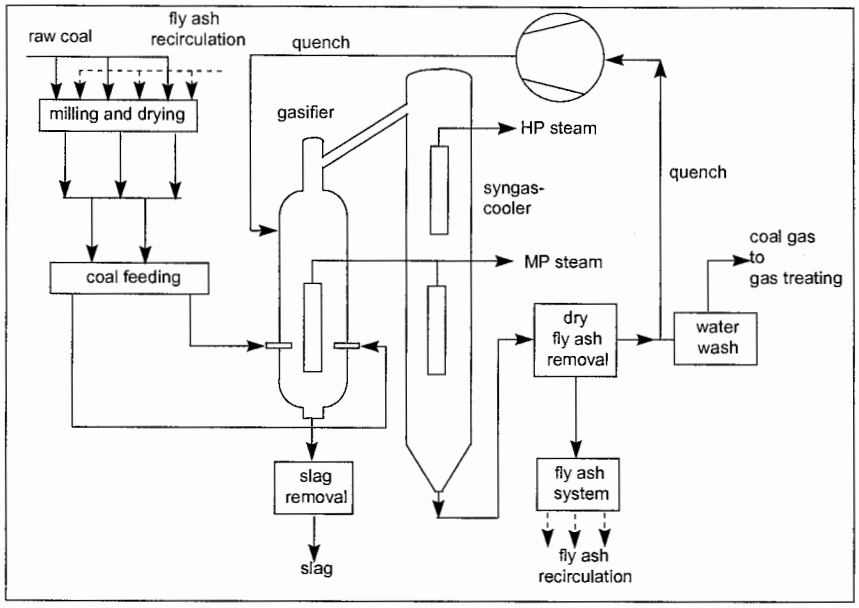


Figure 2 - A typical structure of an SCGP Gasification plant

Shell Global Solution's operational experience with coal gasification started with a 6 t/d pilot plant in Amsterdam, followed by a 150 t/d unit in Harburg, Germany. A third unit in Houston with a capacity of 250-400 t/d fully demonstrated the capability of the gasifier to process a wide range of solid fuels from lignite to anthracite and to petroleum coke. These experiences have led to the successful design, construction and operation of the 2000 t/d coal gasification unit of the Demkolec plant in The Netherlands. Various SCGP plants are at different stages of implementation.

ASSET

The ASSET technology was developed internally for Shell projects and evolved over a period of about 15 years to facilitate improved equipment engineering in the creation of a comprehensive information system for alloys that become corroded by contact with complex, high-temperature gases. ASSET finds wide applications for equipment used in thermal stimulation of heavy oil formations, oil refining, petrochemical processing, and coal gasification.

Joint industry programs are being developed and led by Shell Global Solutions to further advance the technology with the involvement of about 70 other companies, including energy companies, chemicals companies, metals producers, engineering companies, research establishments, and universities from both U.S. and non-U.S.

organizations. Financial support and technological co-operation has been achieved from these companies and the U.S. Department of Energy - Office of Industrial Technologies, as summarized in the table here.

Project	Contribution by INDUSTRY AND US DOE – Office of Industrial Technologies	Time Period
ASSET	$3.8 million	2000 - 2003
Chemical Industry Corrosion Management	$2 million	2003-2005

Project Objectives

- Provide industry-enhanced use of technology in application of metals and equipment design for high temperature processes.
- Enhance/commercialize an information system which assists in predicting the rates of degradation of commercial alloys in complex, corrosive, high-temperature gases.
- Gather corrosion data with the participating companies and add to ASSET
- Generate corrosion data and add to ASSET.
- Use new data to expand the envelope of corrosive conditions and alloys to more fully cover the diverse needs of equipment.
- Enhance thermochemical computations.
- Enhance the capability to predict corrosion behavior.
- Reduce energy consumption in various industrial processes.

Commercialization Plan

The potential users of the product of this project will be chemical process industries that operate processes which involve high-temperature gaseous environments that are capable of causing rapid degradation of the process equipment by oxidation, sulfidation, sulfidation/oxidation, or carburization attack, or by combinations of these modes. Examples can be found in base chemical production, sulfur removal process, and hydrogen production. Since the trend to increased efficiency typically involves the

operation of chemical processes at higher temperatures and the creation of increasingly corrosive environments, the application of an advanced alloy selection and service life prediction system such as ASSET could be very wide.

The commercialization of the project's results will be a constant process over the life of the project. Each company participating in the project will have ready access to the most recent version of ASSET and will be trained in its use. Membership of MTI in the project allows more than 55 companies to access the software as it develops and after it is finished. The initial users of the ASSET technology will be the current ASSET member companies, as well as any other companies that join the project. Additional member companies will be sought throughout the life of the project.

Energy Saving Estimates

The estimated energy savings resulting from the successful implementation of the results of the ASSET project are as follows. One installed unit or unit production = an equivalent chemical facility utilizing in one year, one one-thousandth of the energy used by the entire U. S. chemical industry. A two percent improvement is assumed for the impact of the new technology.

Estimated Energy Savings Table

(a) Energy Source	(b) Current Technology (Energy Used per Installed or Production Unit Per Year)	Proposed Technology (Energy Used per Installed or Production Unit Per Year)
Electricity (kWh)	1.52 E-01	1.49 E-01
Natural Gas (cubic feet)	2.50 E+00	2.45 E+00
Petroleum (barrels)	4.20 E-01	4.11 E-01
Coal (short tons)	1.47 E-02	1.44 E-02

[a]Energy consumed with the current technology.
[b]Estimated energy consumed by the proposed technology.

Environmental Savings from Reduction in Noncombustion-related Emissions

(a) Waste Generated	(b) Current Technology (tons/unit/year)	Proposed Technology (tons/unit/year)
Other Waste Emissions (VOC (metric tons)	2.54 E+02	2.48 E+02

[a]Amount of wastes generated with the current technology.
[b]Amount of wastes generated by the proposed technology.

The technology to be developed may apply in many processes in the chemical industry in addition to the examples cited here. In order to estimate the impact throughout the chemical industry, an OIT GPRA spreadsheet was used. The project can significantly benefit the chemical industry, including improved energy efficiency, reduced cost and improved productivity, and enhanced environmental benefits in the U.S., which will result from the use of the ASSET computational software. The development and use of the ASSET information system will enable enhanced selection and use of optimal materials for utilization as materials of construction in chemical processes.

Chemical Industry Corrosion Management Project

Project Objectives:

- Improved accuracy in equipment lifetime predictions
- Energy savings of 18.5 trillion Btu by 2020
- Improved process safety and operations
- Reduced maintenance costs and expenses
- Reduced emissions of CO_2 and other pollutants

Applications

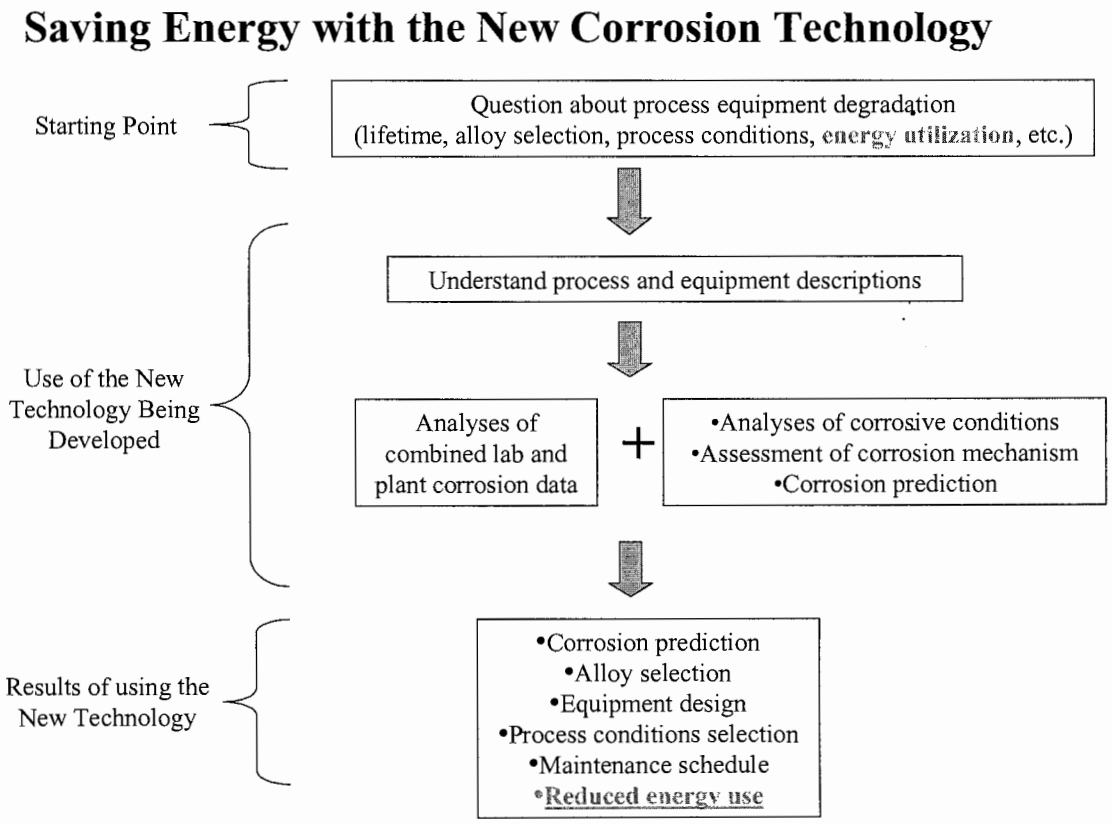
Data for corrosion by Cl_2 and HCl gases and corrosion prediction methods will benefit the forest products and chemicals industry, with applications in chemical processes, incinerators, burning chlorinated materials, and bleaching operations in paper manufacturing. Cyclic oxidation data will be applicable to the chemicals, steel, heat treating, and petroleum industries. Metal dusting data will be applicable to the steel, chemicals and petroleum industries.

Improved Corrosion Management Could Provide Significant Cost and Energy Savings for the Chemical Industry

In the chemical industry, corrosion is often responsible for significant shutdown and maintenance costs. Shutdowns are costly in terms of productivity losses, restart energy, and material costs. These shortcomings could be reduced by improving the capability of engineers to better predict corrosion of alloys under different conditions.

We have a significant opportunity to increase the accuracy used in predicting equipment lifetimes when this equipment is subject to corrosion in high-temperature gases. Researchers are developing corrosion data for commercial alloys, thermochemical models, and increased understanding, which will be delivered to plant designers and operators via an information system to allow industry to comprehensively and reliably predict corrosion. This includes an extensive list of commercial alloys exposed to complex and corrosive gases at temperatures ranging from 200 °C to 1,200 °C.

Anticipated benefits from improving corrosion management are extensive in the chemical industry, many other industries, and for the U.S. economy. Examples are improvements in process safety, reduction in maintenance costs of process operation, more cost-effective use of expensive alloys in equipment designs, reductions in energy use, moderation in the release of CO_2 and other pollutants to the atmosphere, and more confident use of alloys in progressively more extreme operating conditions. With improvements in corrosion management, equipment maintenance will be better scheduled, and unplanned outages due to unexpected corrosion will be reduced. The estimated annual energy savings by 2020 are 18.5 trillion Btu of CH_4.



Corrosion Project Description

The goal is to develop corrosion technology and to deliver it via an information system that will allow industries to better manage corrosion of metals and alloys used in

high-temperature process equipment through improved prediction of corrosion-limited lifetimes and corrosion mechanisms. The project effort in corrosion technology combines comprehensive corrosion databases and thermochemical models and calculation programs to predict the dominant corrosion process. Metal losses by corrosion can then be calculated for commercial alloys over wide ranges of corrosive environments. The corrosion modes to be studied include corrosion by Cl_2/HCl gases, cyclic oxidation, and metal dusting.

The effort will generate several different types of corrosion data. Data for corrosion by Cl_2/HCl gases will be measured under conditions relevant for this mechanism, including temperature, time, gas composition, alloy composition, and mass transport characteristics as influenced by gas flow over metal surfaces. Thermal cycling generally influences oxidation behavior, but it can also promote additional forms of degradation, such as thermal fatigue. Generation of meaningful cyclic oxidation data poses a difficult challenge, due to the diversity of the many potential thermal challenges.

Researchers also intend to create a capability to compile all available data to help in assessments of the tendencies for alloys and metals towards metal dusting in commercial conditions. The aim is to predict metal dusting-limited lifetimes, as defined either by incubation times before onset of metal dusting or by metal loss rates once metal dusting begins.

Milestones

The four main tasks are as follows:

- Software development
- Thermochemical modeling
- Corrosion testing/corrosion technology development
- Commercialization

Commercialization

Developed technology will be transferred to industry through the project's member companies. The effort will be assisted with semi-annual meetings, electronic

communication, software updates and presentations to industry conferences. The Materials Technology Institute (MTI) will distribute the technology to more than 50 chemical companies and their suppliers.

Pulsed Eddy Current Technology

Shell Global Solutions originally developed the Pulsed Eddy Current (PEC) technology as an assist for detecting corrosion under insulation (CUI) through insulation material and metal insulation covers. A number of 'spin-off' PEC applications were also identified over the past few years during this research effort.

The basic principle of operation of PEC is the induction of eddy currents in steel by a magnetic field in the sensor. The PEC probe acts both as magnetizer and detector of the induced eddy currents. A PEC probe is placed above a coated steel object. An electrical current is then introduced in the transmitter coil, which magnetizes the steel surface beneath the probe. Subsequently, the current is switched-off, causing the steel to de-magnetize. The sudden change in magnetic field strength generates eddy currents in the steel, which diffuse inwards from the steel, decaying in strength as they propagate. The induced magnetic field of these decaying eddy currents is detected by a set of receiver coils in the PEC probe, and the signal detected relates to the wall thickness.

PEC wall thickness is an average over the area of the probe's footprint, i.e., a roughly circular area where eddy currents flow. In practice, this means that PEC is well suited for measuring general wall loss. PEC is less suited to detect localized damage such as isolated pitting.

When is PEC suited for an inspection problem?

PEC is particularly suitable for the following situations:

No direct access to the metal surface, due to a layer of insulation, thick coatings, fireproofing, road surface or marine growth that is expensive or impossible to remove and for which removing would serve no other purpose.

Surface preparation: PEC does not require surface preparation, which is a crucial advantage in splash zone and underwater applications.

Access: Conventional methods are often not applicable if access is difficult or restricted. PEC is more suited than alternative techniques for deployment by remote access via jigs, suspension on cables, abseilers, ROVs and 'key hole probes'. This relates to the tolerance against misalignment of the PEC probes with respect to the steel surface.

Monitoring, especially at high temperature: PEC is uniquely suited for in-service monitoring of steel.

The technical feasibility of PEC relates to:

- Nature of the degradation PEC can detect and size general corrosion, but often fails to detect more localized corrosion.
- Complexity of the geometry: PEC is best suited for 'simple' geometries, i.e. straight sections of pipes without any nozzles and supports. It is possible, but more difficult, to apply PEC around more complex geometries.
- Thickness of the insulation: the thicker the insulation, fireproofing etc., the more difficult it is to apply PEC.

Based on the utility and technical feasibility, the PEC applications can be categorized as follows:

Regular Applications

Corrosion monitoring
Splash zone inspection of coated risers and caissons
Under water inspections of caissons by remote operated vehicle (ROV)
Measurements through coatings and fireproofing
Well tubular inspections (offshore)
Key-hole inspections (e.g. annular rings storage tanks)
Measuring remaining wall thickness through corrosion products
Corrosion under insulation
High temperature inspections of a vessel (not corrosion monitoring)

Niche Applications

Delamination (few applications only)
Detection of cracks in welds (e.g. for inspection of orthotropic steel bridges)
Detection of geometrical anomalies (e.g. frame detection of sunken ships)

Technical Progress Over the Last Three Years

The Research and Development of the PEC team of Shell Global Solutions has led to a number of improvements to the PEC technology. This program also led to seven patent applications.

The main technical improvements are:

Patents have been filed for the focused probe design. This design reduces the footprint by about a factor of five with respect to other probe designs.

PEC profiling is being developed. PEC profiling further enhances the defect sensitivity for external corrosion.

Keyhole probes have been developed. These probes allow inspection in locations with restricted access.

A method has been developed to make PEC highly reproducible. Ä patent application has been filed on PEC corrosion monitoring.

Directional Pulsed Eddy Current is being developed for crack detection applications.

Portability

A unique feature of PEC is its portability. With PEC, a single sensor can be used to monitor many different locations. Positioning frames and center pop marks are used to ensure that the PEC probe is accurately located in the same monitor position each measurement.

The portability of PEC has important advantages over alternatives:

- Robustness. No fixed parts

- Economical. Costs are saved by using just one set of equipment for many different locations
- No problems with high temperature (tested up to 420 °C)
- Installation: can be done while the equipment is running; no need for welding.

PEC probes are also available to monitor wall thickness at fixed positions. These are used to determine corrosion rates in areas where it is difficult to use the mobile PEC probe (e.g., in areas where scaffolding is required). The method is illustrated with Figures 3 and 4.

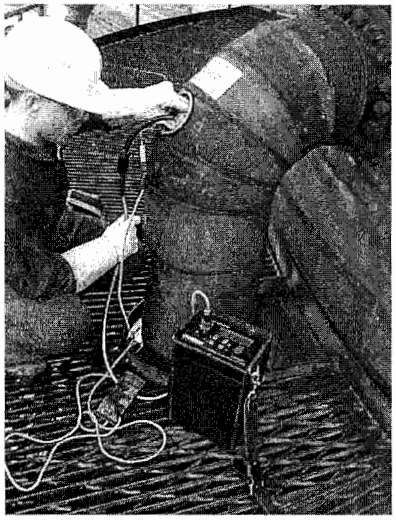


Figure 3- PEC monitoring

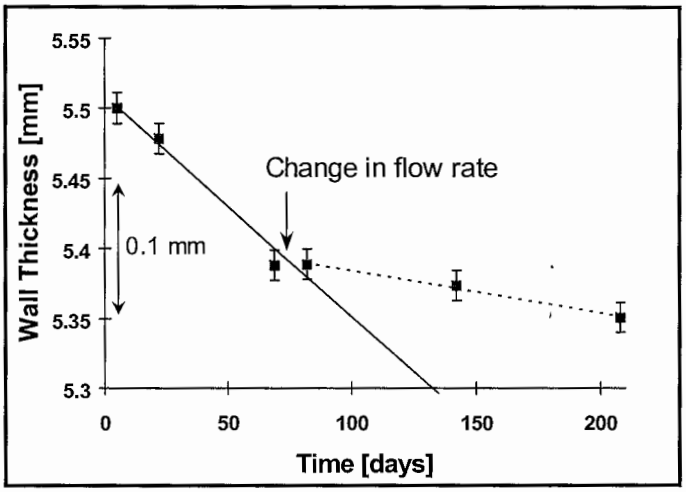


Figure 4 – Data collected over time

In the photo (figure 3), data collection is shown in progress on an insulated pipe operated at 320°C. The operator places the PEC probe on a measurement position that is defined by a positioning frame or by center pop points on the pipe surface. The result of six such measurements recorded over a time span of 200 days is displayed in the accompanying graph (figure 4). Note the expanded wall thickness scale.

PEC corrosion monitoring probes can also be fixed to pipes. For hot insulated pipes, the probes are strapped to the insulation; otherwise, probes are simply and directly strapped to the pipe.

Environment Remediation and Sustainability

Shell Global Solutions has active applied research underway in the Houston area for environmental remediation and sustainability. At the Shell Westhollow Technology

Center, we continue to create more efficient and cost-effective site remediation methods for petroleum in the environment, including low-intensity biological remediation processes.

To promote sustainability concepts, Shell established Rice University's new Shell Center for Sustainability last fall through a $3.5 million endowment from the Shell Oil Company Foundation. Building on the Environmental and Energy Systems Institute's interdisciplinary program of education, research and outreach, the Shell Center focuses on the role of the private sector in implementing a sustainable future.

Royal Dutch/Shell Chairman Sir Philip Watts spearheaded the development of the center and also addressed the first conference held in March of this year. One of the primary goals of the new research center is to develop established methods or practices that industry can follow in order to foster sustainability.